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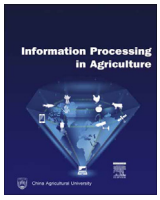

Management and control applications in Agriculture domain via a Future Internet Business-to-Business platform

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ABSTRACT

The Agriculture business domain, as a vital part of the overall supply chain, is expected to highly evolve in the upcoming years via the developments, which are taking place on the side of the Future Internet. This paper presents a novel Business-to-Business collaboration platform from the agri-food sector perspective, which aims to facilitate the collaboration of numerous stakeholders belonging to associated business domains, in an effective and flexible manner. The contemporary B2B collaboration schemes already place the requirements for swift deployment of cloud applications, capable of both integrating diverse legacy systems, as well as developing in a rapid way new services and systems, which will be able to instantly communicate and provide complete, "farm-to-fork" solutions for farmers, agri-food and logistics service providers, ICT companies, end-product producers, etc. To this end, this conceptual paper describes how these requirements are addressed via the FIspace B2B platform, focusing on the Greenhouse Management & Control scenarios.

1. Introduction

ICT and agriculture originate from disparate human needs, nevertheless, the first domain proves to be of upmost significance to the second in order to facilitate modern complex business processes related to agriculture. ICT application in agriculture has been an emerging field for some years, attempting to enhance the agricultural processes through sophisticated information and communication developments. Aspects of the agriculture industry such as crop cultivation management and control, quality management, transport of food products and food preservation may all be enhanced by taking into account their domain-specific requirements and translating them into the respective functional design, development and applications by ICT experts.

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Several efforts over the last years have attempted to integrate end-to-end ICT solutions into the agriculture business processes. Smart farming, precision agriculture, Farm Management Information Systems (FMIS), all are terms, which introduce the notion of sophisticated processes using advanced information and communication tools and systems into agriculture processes, previously unexploited. Analyses of potential developments in the precision agriculture domain have taken place taking into account spatial and temporal variations. Examples of existing site-specific precise farming approaches, using dynamic, real time, adjustable approaches as well as future directions for such developments have been described ([1,2]). With regard to existing solutions, a considerable amount of efforts is focusing on wireless sensor networks solutions for monitoring the condition of the crops during production, for product autoidentification, as well as for the transport of products condition monitoring ([3–5]). The main operations, which are in general dealt within the context of Precision Agriculture and Greenhouse Management are data monitoring, data processing, knowledge inference and finally knowledge transfer back to the farm or greenhouse and execution of the generated actions. In principle, a typical solution comprises a wireless sensor network residing inside the farm or greenhouse, while at the other end there is a database, as well as a processing component, such as an expert system, which is processing the available data and generates actions – often in an automated manner – for the farmer. Modern business processes related to agriculture and greenhouse management and control involve multiple stakeholders, enterprises, as well as external back-end systems. The complexity of those business processes is nowadays the most crucial challenge that needs to be coped with. Several sophisticated Farm Management Information Systems' solutions and architectures have been already described in the literature ([6–8]). However, most of the existing schemes limit their functionality to a very narrow aspect of the overall business process, isolating the business actors and thus, not being able to maximize the potential outcomes.

In [9] the authors describe a novel architecture, which takes advantage of the Future Internet Public–Private Partnership (FI-PPP) ([10]) capabilities in order to facilitate the interoperability among services and stakeholders. In the afore-mentioned work, it is aimed to demonstrate how the adoption of these general-purpose software modules provided by FI-PPP and their extension into farming specific ones may provide a cloud operating system that can integrate different services and applications. In [11], a detailed analysis of the FI-PPP software modules exploitation is provided according to the deployments in the context of the Smart Agri-Food (SAF) FI-PPP Phase 1 project ([12]). An operational example is used to demonstrate the interworking of the functional modules of the architecture, as well as corresponding business actors and events. In [13] the implementation of an innovative, open and flexible, cloud-based Farm Management System is provided, along with a framework that allows the interconnection among services developed by different service providers.

Another FI-PPP Phase 1 project related with the Smart Agri-Food project presented earlier, based on the FI technologies as well but focusing on the domains of transport and logistics is FInest ([15]). The aim of FInest was to define realistic business scenarios illustrating how transport business operations could be conducted and facilitated through the help of a FI-based collaboration platform. Different use case scenarios were used to demonstrate the capabilities of the FInest architecture in real-life: handling late booking cancellations, resource coordination, real-time event handling, e-planning, as well as automated shipment tracking.

Another significant perspective, in parallel to the actual developments and technology choices presented earlier, is ultimately being able to offer to the end-users (i.e., farmers, greenhouse managers, etc.) and/or domain business stakeholders the capability to search for and use specific services and applications according to own needs and requirements, from a centralized repository of services/apps, namely an "app store". An app store usually offers a variety of choices among apps, in a similar manner the famous Apple Store ([16]) or Google Play ([17]) offer. In the agriculture domain, AgWeb app store ([18]) offers a considerable number of agri-food chain-related apps specializing in different fields such as agronomy apps, farm business apps, machinery, weather, etc. What is actually missing, however, is a unified underlying infrastructure, which supports the execution of the offered apps, lacking this way in homogeneity, usability and user friendliness. Even in the case of Google Play or Apple Store, although there is a single platform to support the several apps (Android or iOS respectively), the apps are developed in a completely independent and separated way from one another, lacking any business collaboration model behind them to link their requirements, actual execution, or results and offer a complete end-to-end solution.

Although prior efforts do attempt to address some of the high challenges of the business processes either in the domain of the agriculture or the logistics exclusively, what is actually missing is a holistic, end-to-end solution, which is capable of bridging the diverse gaps between different – but directly associated – domains, such as the afore-mentioned ones. The increasing complexity through the agri-food supply chain processes, involving more and more business actors and stakeholders, as well as multiple and often complex interactions between them establish completely new needs – previously unseen. In all cases presented earlier, the proposed schemes attempt to partially enhance a narrow aspect of the overall supply chain picture, failing to provide a holistic solution, in which any stakeholder is able to take advantage of a specific business collaboration model, as well as select and deploy the desired means (apps, services) to accomplish it. Future systems cannot rely on existing infrastructure and require more sophisticated and smart frameworks in order to improve the effectiveness of business processes. Current trend is gradually heading toward the Internet capabilities in order to address several of the existing limitations. However, handling vast number of devices (i.e., Internet of Things domain), as well as realizing an efficient communication scheme between the involved stakeholders of the business chain still remain some of the most significant obstacles.

In this paper, an advanced architecture based on the Future Internet developments is presented, which aims to

provide an end-to-end, integrated and extensible "Platform as a Service" (PaaS) for stakeholders and business players belonging to diverse business domains, which collaborate in order to fulfill a complete business case: FIspace ([19]). The main idea of FIspace is that any business collaboration is "built" around "business entities (BEs)", while diverse domain-specific apps and services are deployed and configured in accordance with these business entities, which will be described in the following sections. Various use case scenarios are applied in the context of FIspace, in order to evaluate specific key performance indicators, focusing on multiple business domains: crop protection information sharing, greenhouse management and control, fish distribution and (re-)planning, fruit and vegetables quality assurance, flowers and plants supply chain monitoring and meat information provenance. Although, the platform supports multiple domains in order to support the complete supply chain "from farm to fork", the current work emphasizes on the greenhouse management and control use case trial of the FIspace project.

The rest of the paper is organized as follows. In Section 2, a description of the Future Internet PPP developments is presented. Section 3 provides an overview of the FIspace platform, a reference architecture for Business-to-Business (B2B) collaboration in supply chain networks is described including a methodology (i.e. the FIspace operational model) that can be seen as a kind of handbook of how this reference architecture could be implemented. In Section 4, we focus on the greenhouse management and control trial, demonstrating how the FIspace platform is exploited in order to facilitate B2B collaboration scenarios related to the agricultural, and how all the involved agri-domain business actors may benefit from such a B2B platform via novel, smart applications deployed inside FIspace. In the final section, we summarize the conclusions, which are derived and insights on the next steps are provided.

2. The Future Internet Public–Private Partnership (FI-PPP) and FI-WARE Generic Enablers

In the attempts discussed earlier, the FI-PPP plays an essential role toward creating the required communication and technological infrastructure for supporting a complex and holistic stakeholder interaction in the context of business collaboration processes. Future Internet refers mainly to an initiative, which performs research activities to create novel architectures for the Internet, ranging from small, incremental steps to complete architecture and principles' redesigns. Research activities that could be seen as components of a future Internet include network management, network virtualization, and treating any kind of information as objects, independent of their storage or location. FI-PPP mainly targets toward the digitization of the European economy sectors including agriculture, transport, logistics, smart cities, e-Health, safety, manufacturing, tourism, energy etc. Through cloud solutions, apps' repositories, semantic tools or big data handling, it aims to create a core platform consisting of various "sub-platforms" and sub-modules, in order to facilitate the creation of novel applications built on top of the existing infrastructure features. The vision of FI-PPP is based on FI-WARE and FI-LAB ([14]), – an ecosystem, which engages both developers and entrepreneurs and provides the required tools to support it. General-purpose software modules – known as "Generic Enablers" (GEs) – support the infrastructure of FI-WARE. These GEs are the building blocks of the core platform and are categorized according to their principal scope to several categories such as:

- Applications/Services Ecosystems GEs (e.g., Application Mash-up, Business Calculator, Repository GE etc.): Supports the creation of an innovative ecosystem of applications and services.
- Cloud Hosting GEs (e.g., Job Scheduler, Object Storage GE, etc.): Enables the implementation of modern FI applications, compliant with cloud hosting infrastructure.
- Security GEs (e.g., Access Control, DB Anonymizer, Identity Management GE, etc.): Enables the implementation of the required security mechanisms for each app to be developed.
- Data/Context GEs (e.g., Big Data Analysis, Complex Event Processing, Semantic Annotation, etc.): Enables the exchange and publication of massive data in a fast, yet efficient way.
- Internet of Things GEs (e.g., Gateway Data Handling, IoT Broker GE, etc.): Helps the "things" connection to the real world by becoming available, searchable, accessible, and usable for FI uses and services.
- Device/Network Interfaces GEs (e.g., Cloud Edge, Network Information and Control GE, etc.): Establishes an open and standardized network infrastructure.

FI-LAB is a use case example of FI-WARE instance, providing cloud-hosting capabilities for third parties in order to be able to experiment with Future Internet applications. Furthermore, via the FI-LAB environment Generic Enablers implementations are available and globally accessible as services. Often, the user can select among more than one implementation of a Generic Enabler is available from different providers. Each one of the GEs is licensed with no costs within the FI-PPP program, while diverse terms and conditions are applied among the various GEs for external use.

3. The FIspace platform and the FIspace operational model

3.1. *FIspace Platform high-level architecture*

FIspace is a Business Collaboration Network in agri-food, transport and logistics aiming to provide an innovative business space, based on the Future Internet technologies, and allowing seamless collaboration between multiple business actors. It may be described as a business-to-business software tool, comparable to Facebook or LinkedIn. Business can interact with each other, start and accomplish collaborations, exchange information, communicate and coordinate activities. The high-level architecture of FIspace platform is demonstrated in Fig. 1.

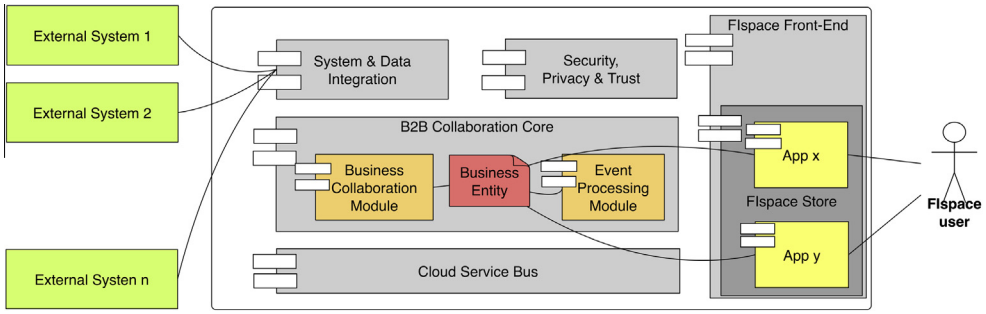

Fig. 1 – FIspace high-level platform architecture.

As it is illustrated in the architecture above, the platform is comprised of six fundamental modules:

- The Graphical User Interface (Front-End): the main access point for the end-users, which provides all the essential features for the business collaboration, access to FIspace App Store, notifications mechanism, reputation and recommendation mechanisms, etc.
- The FIspace Store: the access point from which the FIspace apps are available for provisioning, consumption and purchase both for consumers as well as the FIspace app developers.
- The B2B Collaboration Core module: it is one of the core components of the platform, on which the business collaborations rely on. It is comprised of
  - o the Business Collaboration Module (BCM): this module serves the principal real-time B2B collaboration concept; its purpose is to create, handle and manage the FIspace collaboration processes [28].
  - o the Event Processing Module (EPM): A complex event processing engine that monitors and tracks after events of interest related to the business collaboration.

- The System and Data Integration module: the "gateway" of any external or legacy systems (e.g. Internet of Things) in order to communicate with the FIspace platform and participate in a business collaboration.
- The FIspace Cloud Service Bus (CSB): another essential core module, which facilitates the connecting between all the main components of the platform.
- The Security, Privacy and Trust (SPT) module: it is concerned with all the essential features in order to provide all the required security mechanisms in order to ensure a reliable exchange of business information and transactions.

According to the previous section, the FIspace platform is acting as a "specific enabler" of FI-WARE, as several of the core components of the platform is relying up to an extent to a generic enabler. Although the platform development is still ongoing, several GEs are already used, and this number may also increase as the developments progresses:

- Part of the FIspace Front-End is based on the Wirecloud GE ([20]), an "application mash-up" platform.
- The FIspace Store is built upon the WStore GE ([21]), which respectively connects to Repository, Marketplace, Registry, Identity Management and Revenue Sharing GEs ([22–25]).
- The Event Processing Module (EPM) core module implements the Complex Event Processing (CEP) GE ([26]).
- The System and Data Integration Module is using the Mediator GE ([27]), which facilitates the interoperability among different communication protocols and data models.
- The Security, Privacy & Trust Module is based on the Identity Management GE mentioned earlier, taking care of the secure access to the FIspace networks, integrated user authentication mechanism etc.

The figure that follows (Fig. 2) illustrates the relationship between FI-WARE developments, FI-LAB, Generic Enablers and FIspace platform, being one of the Specific Enablers example.

3.2. *The B2B collaboration core*

The aim of this module is to create, manage, execute, and monitor collaborative processes in the FIspace platform. To this end, two complementary components are implemented: The Business Collaboration Module (BCM) and the Event Processing Module (EPM).

The BCM component is responsible to orchestrate the different processes from different stakeholders and assure the

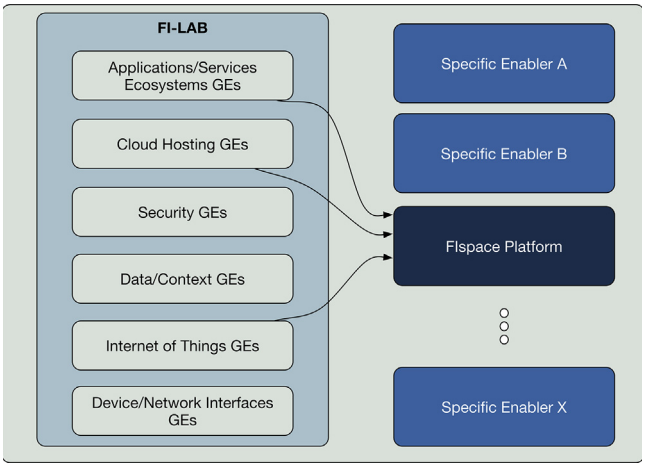

Fig. 2 – FI-WARE FI-LAB' GEs and FIspace Specific Enabler.

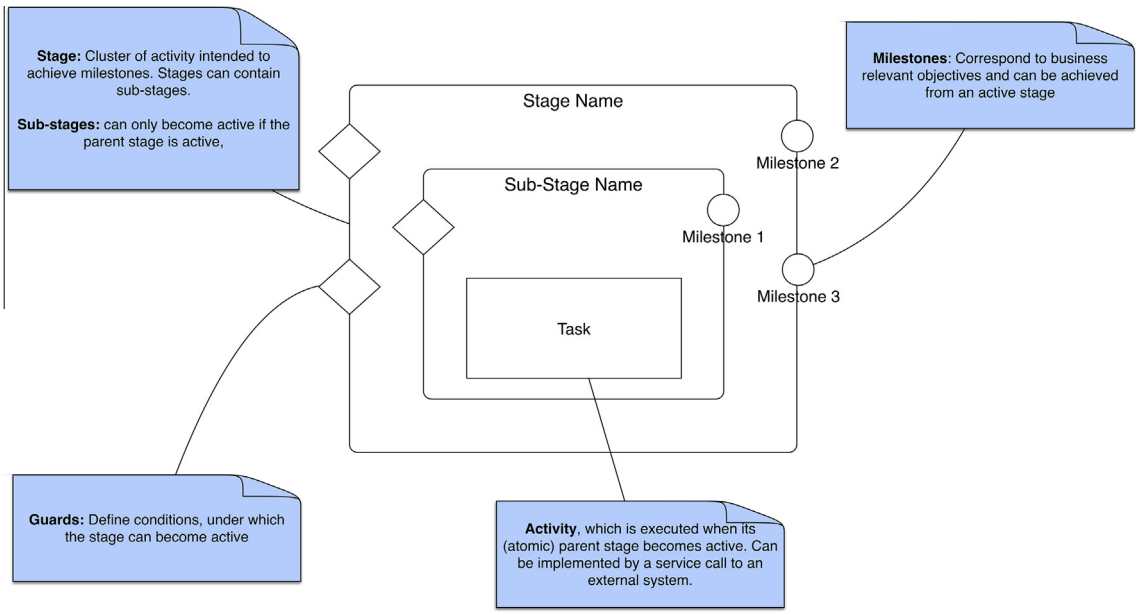

Fig. 3 – GSM model for describing the lifecycle of a business entity.

correct sequence of the tasks execution. The BCM is based on the entity-centric approach [28]. This approach relies on the notion of *entities* (aka, as business entities, artifacts, or dynamic artifacts). A business entity is a key concept that evolves as it moves through a business process. An entity type includes both a data schema and a lifecycle schema, which are tightly linked. The data schema provides an end-to-end conceptual view of the key data for this entity type. The lifecycle schema of an entity type specifies the different ways that an entity instance might evolve as it moves through the overall process. In FIspace we apply the GSM – Guard, Stage, Milestone-model ([28]). GSM is a declarative model that enables hierarchy and parallelism of the tasks and reactive in nature, that is, the tasks flow as a result of triggering events to specific conditions. The main constructs of the GSM model are illustrated in Fig. 3. Stages represent clusters of activity and are visualized as rectangles with rounded corners. Each Stage can own one or more Guards, which control its activation. Guards are defined as conditions of the form "on <event> if <condition>" (visually represented as diamonds). Stage can have one or more Milestones. They represent the achievement of distinct business objectives and are visually represented as circles. Like Guards, they are noted in the form "on <event> if <condition>".

In the Greenhouse scenario in FIspace we defined *Advice* as our key business entity related to the Greenhouse Management & Control scenarios to demonstrate in a more specific way how a GSM model may define the greenhouse management workflows processed by the FIspace platform.

The Event Processing Module (EPM) component monitors events and detects situations of interest, i.e. situations that require appropriate actions. The events sources (aka event producers) can be the actual execution of the collaboration (i.e. the BCM), external systems, or sensors. The EPM processes these events and by applying pattern matching derives situations of interest ([29]). Examples of situations of interest can be: missing documentation at a certain point in time, a sensor reading outside a permitted range, a delay in a delivery etc. In general, we can distinct between situations that result from the actual execution of the process or collaboration and situations that result from external events (i.e. events coming from external systems or sensors).

The EPM can support two types of situation detection capabilities: reactive and proactive. Reactive rules analyze past events and derive situations by applying pattern matching over a single or a set of events over time. Proactive rules, on the other hand, relate to situations that are likely to happen in the (near) future. In general, we refer to proactive event-driven computing as the ability to mitigate or eliminate undesired states, or capitalize on predicted opportunities – in advance. This is accomplished through the online forecasting of future events, the analysis of events coming from many sources, and the application of online decision-making processes ([30–33]).

3.3. *FIspace operational model*

The business collaborations within FIspace platform heavily rely on the respective business entities, which were described in the previous sub-section. However, these business entities reside within the platform, acting internally; as a result the end-users are not supposed to interact with them directly. In order to realize the collaboration among business actors and take advantage of the business entities, apps are developed and available to the FIspace users via the FIspace Store. The apps are built within a generic context and are not supposed to be linked to specific external systems. In order for them to be usable, the business user needs to instantiate (configure) them according to own needs,

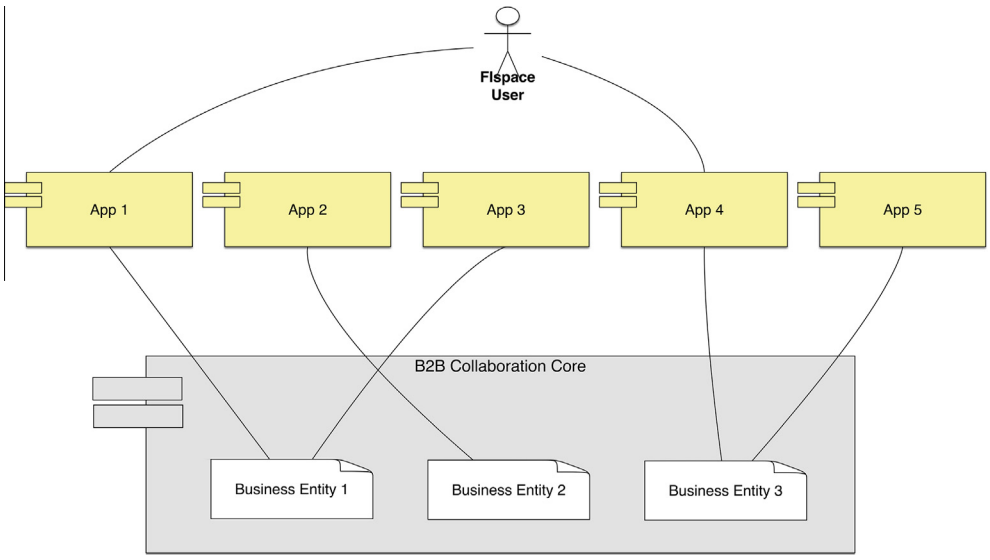

Fig. 4 – The FIspace Operation Model between the business entities and the FIspace apps.

mapping specific external systems for a respective specific instance of the business entity.

The above process describes the fundamental operational model of FIspace. A business entity may be linked to multiple FIspace apps, which will consume events produced within this business collaboration. Respectively, there is the possibility for one FIspace app to be linked and consume events from more than one business entity. For instance, assume there is a business collaboration between a greenhouse owner (or farmer), a weather service provider, as well as an expert (advisory) system, which provides actions to be taken inside the greenhouse to the farmer according to the environmental conditions (provided by sensors inside the greenhouse). FIspace could support multiple apps linked to this particular collaboration: Firstly, an app, which shows the conditions inside the greenhouse could be developed. In addition, a second app could illustrate the weather information provided by the weather service. Finally, a third application could be deployed in order to receive from the expert system the advised actions and provide them in a proper way, using probably notifications mechanism, to the farmer. A scenario, similar to this one, will be presented in detail in the next section. Fig. 4 below illustrates the connection between the apps and the FIspace business entities.

4. The Greenhouse Management & Control scenarios

Real-world business scenarios are established in order to evaluate the FIspace platform, in the context of which, several generic as well as domain-specific applications are developed according to the platform's operational model. The purpose of these implementations is to test whether the underlying infrastructure is able to deliver the required functionality, performance, security, privacy and reliability for the business stakeholders of the agricultural domain (in the case of the Greenhouse trial scenarios) to rely on and expand their activities using the FIspace technologies.

The use case trials primarily originate from two business domains, i.e., agricultural domain and transport and logistics. Notably, they are categorized along three "themes":

- "Farming in the cloud", focusing on the agricultural domain
- "Intelligent perishable goods logistics", focusing on the transport and logistics domain
- "Smart distribution and consumption", also focusing on the transport and logistics domain

This paper focuses on the "Farming in the cloud" theme, and in particular on the greenhouse management and control use case trial. The scope of the experiment is the management and control enhancement of greenhouse operations, aiming at demonstrating how the Business-to-Business collaboration among the domain stakeholders via the FIspace features, increases the agricultural productivity and revenues as well overall facilitates the several processes. In the context of the Greenhouse Trial, different scenarios take place, in order to demonstrate numerous aspects of the domain that may be enhanced using the FIspace infrastructure. These scenarios are summarized as follows:

- Requesting for greenhouse advice from an expert system
- Managing consumer complaints
- Facilitating new collaborations between stakeholders
- Recalling a product using traceability mechanisms

For each one of the above scenarios, a number of diverse business stakeholders are participating, i.e.: farmers, greenhouse managers, advisory services enterprises, agronomists, end-product producers, Farm Management Information

System (FMIS) owners, an agricultural state agency, a weather service, as well as a product traceability platform.

What is going to be tested, is whether and to which extent, certain Business KPIs are improved. The farmers must be able to organize the task planning of their greenhouses in an automated and more sophisticated way; the interconnected advisory services must inform via the FIspace Domain Specific Apps the farm managers of forthcoming alerts and actions to be taken; health hazards must be identified and relevant stakeholders must be notified in a timely manner; Greenhouse domain stakeholders must be able to discover new potentials for collaborations (with farmers, end-product producers etc.) and create new Service Level Agreements in a much more efficient as well as sophisticated way.

Overall, via the use cases, which will be presented below, it is expected that:

- Farm managers/Farmers will be able to manage their greenhouses in a more efficient way, handle their tasks more efficiently retrieving information from multiple back-end systems, weather services, advisory systems, all of which will collaborate in order to produce the best possible feedback to the stakeholder, which will potentially enable him to maximize his revenues
- End-Product producers will be able to discover potential partners that interest them in a much more efficient way, retrieve updated information about products and be notified for any emergency situations concerning their products
- Legacy/Back-end systems' owners will deploy their systems in multiple collaboration chains, maximizing their products' usage and thus, revenues
- Developers will be able to upload via the FIspace Store their apps, which will be used by the various business collaborations
- Various business actors who will be involved in the different scenarios like Consulting Firms, State Agencies etc. will also gain profit from participating in such collaborative chains
- Appropriate information that is related to farmers' profiles could be exchanged automatically with states' and information policies enabling to simplify daily routines. For example, a direct link between a farmer and the state agency would eliminate bureaucracy.

4.1. *Requesting for greenhouse advice from an expert system*

Two main business actors are involved in the first scenario (Fig. 5): the farmer/greenhouse manager and an advisory/expert system enterprise, which provides advisory services to the greenhouse based on the conditions inside the greenhouse. In the archimate model above, the business layer of the collaboration is illustrated (yellow color), as well as the technology/infrastructure layers (gray layer at the bottom). The main blocks in the technology layer are FIspace, the Greenhouse FMIS, and the Advisory Service. Inside the FIspace platform an "Advice Request" app resides, which corresponds to respective business collaboration and provides the information via the UI to the farmer.

The idea is that the sensors' values of the Greenhouse are forwarded to the Greenhouse Farm Management System (FMIS), where they are contextualized, and afterward they are forwarded to FIspace. In case of events inside the greenhouse (i.e. sensor values detected out of predefined boundaries) a request for actions is sent to the advisory system. The end-user receives the actions from the expert system via the respective FIspace app. The message sequence chart (MSC) that follows, describes the particular process (Fig. 6). This specific business collaboration is handled by the advice business entity, which is illustrated later in the paper.

Such a business process, although being a simple business case by involving only two stakeholders, targets to illustrate a radical enhancement, in principle with regard to the time required accomplishing it, as well as the quality and the

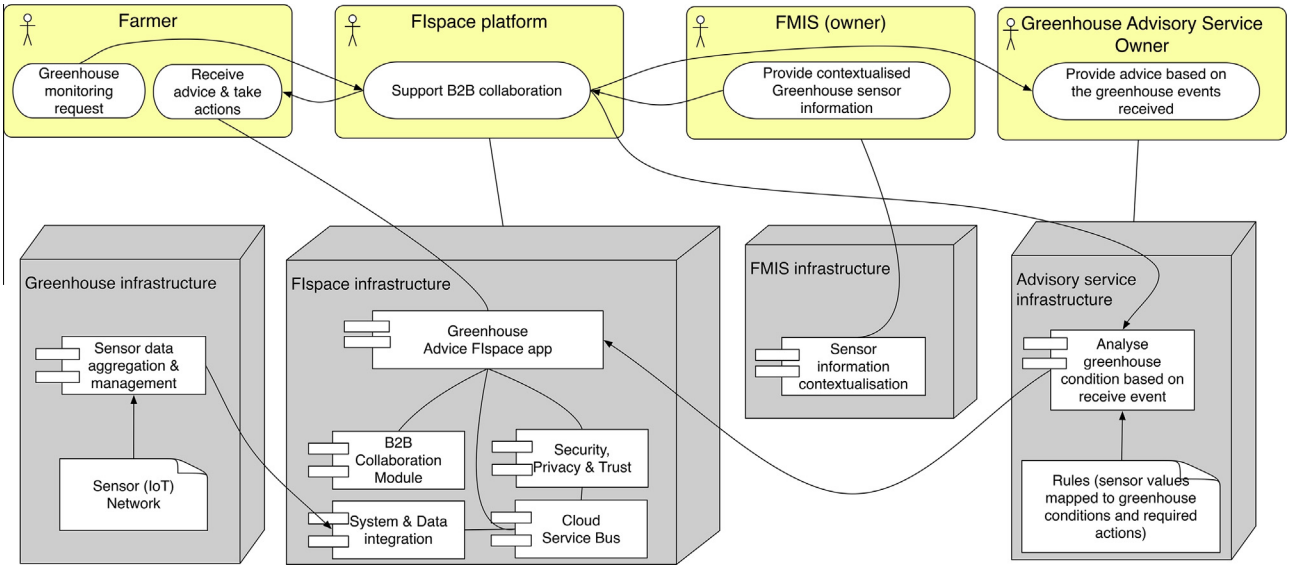

Fig. 5 – Collaboration (business and technology layers) for Advice Request from expert system for actions to be taken inside the greenhouse.

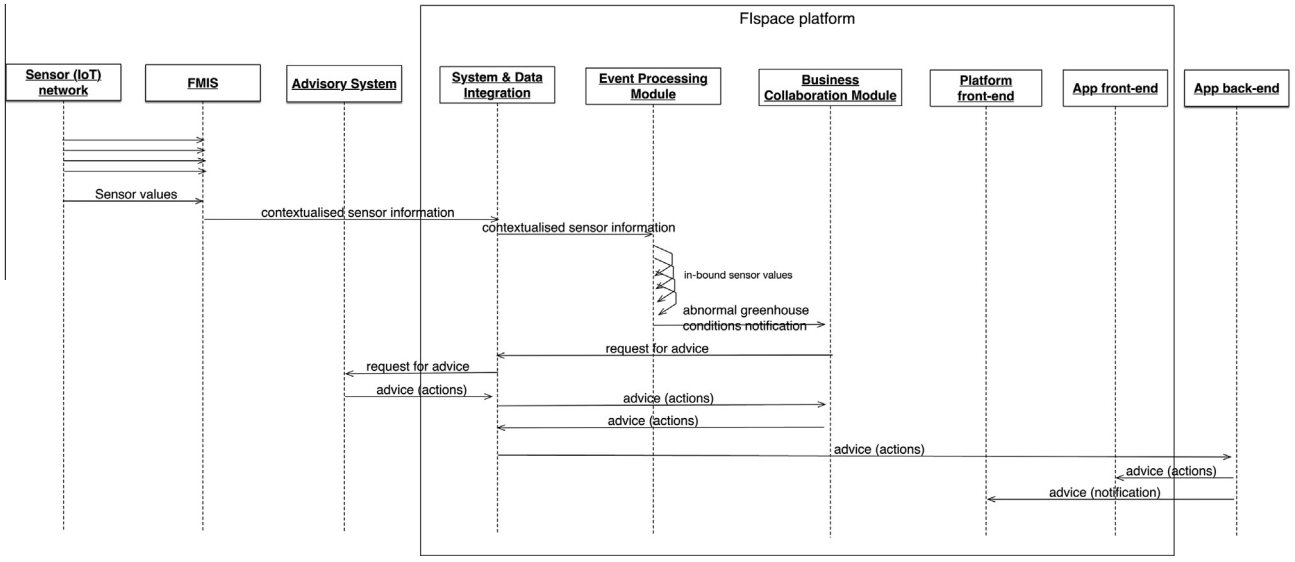

Fig. 6 – MSC for the Greenhouse Advice Request scenario.

accuracy of the actual advice actions. This will result, consequently, to higher profits for all involved stakeholders; on the one hand the farmer, but on the other, the advisory system owner as well, who based on the quality of the services will have the possibility to increase the collaborations with interested parties. Notably, the concept of the platform architecture and operational model provides the opportunity for further enhancing the outcome of the particular business collaboration by deploying more business players and external systems to participate in the same business entity. Indicatively, a weather service could be linked to the platform – using the respective adapter – and provide information to the advisory service, so that ultimately the information forwarded back to the farmer is enhanced. Similarly, a logistics service could connect to the existing business entity in order to get updates with regard to the conditions inside the greenhouse, when trying to trace food quality issues created during the supply chain.

4.2. *Managing consumer complaints*

In the Managing Complaints scenario (Fig. 7), an end-product producer receives a complaint from a consumer. The Managing Complaints collaboration is managed inside the platform by the complaint business entity. The end-product producer uses the Managing Complaints FIspace app to submit the complaint and receive a respective analysis on it from a traceability service (TS) provider, a back-end system provider as well as a Consulting Firm. Instead of having to send separately the complaint report to each one of the aforementioned business actors, the specialized FIspace app receives the complaint, and – based on the respective business entity configured inside the platform – forwards the appropriate requests accordingly to the required systems.

The Message Sequence Chart, which follows (Fig. 8), further elaborates on the particular scenario and the interaction of the diverse systems and the FIspace platform:

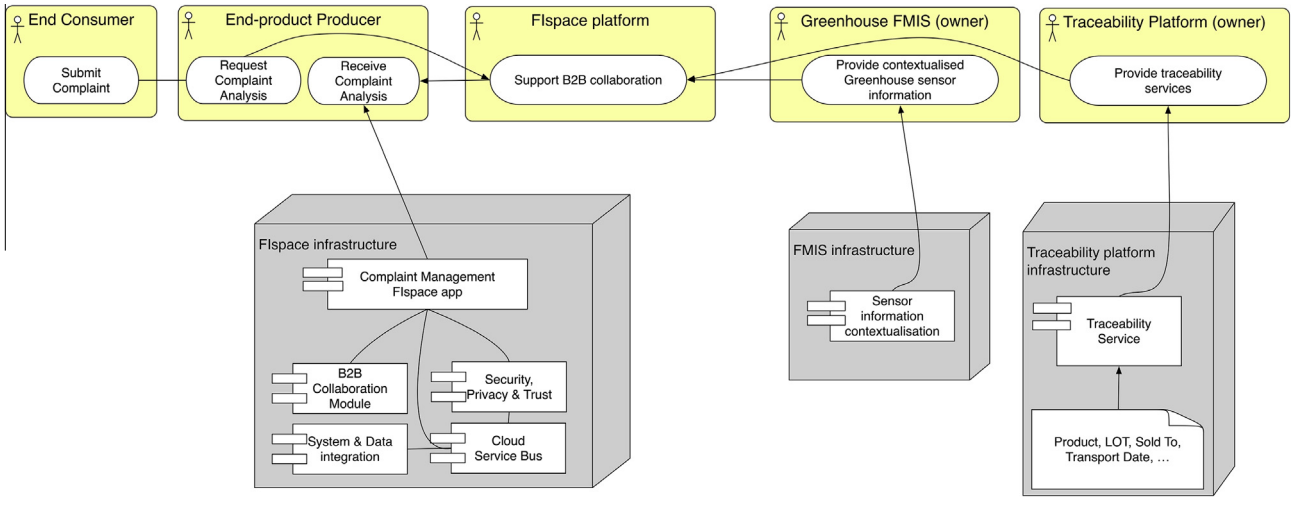

Fig. 7 – Collaboration for Complaint Management from an end-product producer.

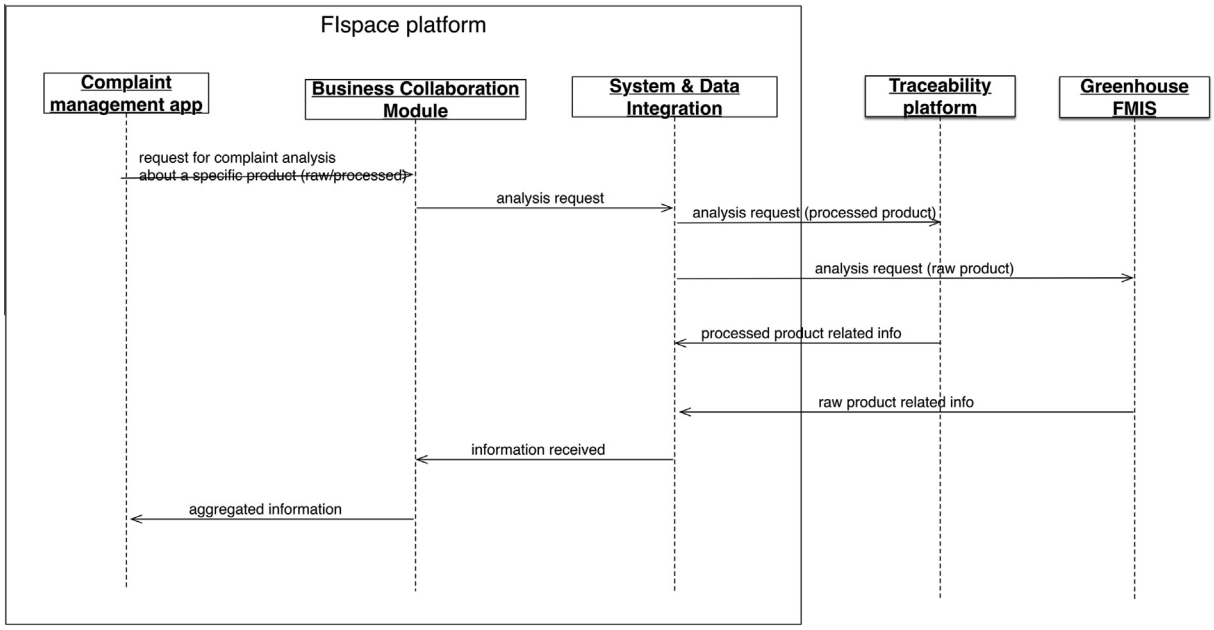

Fig. 8 – MSC for the Complaint Management scenario.

The Business Collaboration core module receives the request from the Complaint Management app's back-end and dispatches the request via the System and Data Integration (SDI) module (i.e., the platform's "gateway") to the respective external systems: the information regarding the raw product part of the request will be forwarded to the Farm Management Information System of the greenhouse, while the processed product's part to the traceability platform. Similarly, via the SDI module the information is aggregated inside the Business Collaboration module and transferred back to the back-end of the Complaint Management app, which via the app's respective front-end provides the required info to the user.

4.3. *Facilitating new collaborations between stakeholders*

Discovering the ideal business players to collaborate with for accomplishing diverse business processes is not a simple task. Often, multiple parameters need to be taken into account (location, availability, specialized services etc.) and the whole process (i.e. by the time an end-product producer enterprise begins to search for new farmers-suppliers for example until an SLA is established) may take very long time. Using the Marketplace Operations service within the FIspace platform, any business stakeholder is able to select among the domain of preference (e.g. agriculture – greenhouse products), the location, the period of the collaboration in which one is interested and directly make a request to FIspace. The platform – via the Marketplace Operations – is querying the already created service offers or demands, as well as forwards the query to external systems, which have been integrated and connected to FIspace; in the particular scenario (Fig. 9), the farmers' database of a State Agency of Agriculture is used. Many e-marketplaces and/or databases can ultimately integrate with the Marketplace Operations service of the platform, providing the highest-quality possible services to the interested business partner. In addition to the above, an automated match-making mechanism between available offers and demands is available, in order to notify the interested parties for existing services, which may possibly satisfy their requirements. The implementation of the Marketplace Operations back-end is heavily relying on two GEs from FI-WARE: the Repository GE and the Marketplace GE, which are used for storing the service information in the RDF semantic web standard [34].

Similarly with the previous scenarios presented above, the MSC of the specific use case is demonstrated in Fig. 10 below:

An example of an initial creation of a service offer by user A and a service demand by user B sometime later is illustrated. The existing offer created by user A satisfies the demand, which is submitted by user B. The match-making mechanism within FIspace provides an instant notification to both users for informing them so that they possibly proceed to the creation of a new collaboration.

4.4. *Recalling a product using traceability mechanisms*

In this scenario (Fig. 11) it is assumed that an emergency event breaks out and needs to be dealt with in a timely manner. More specifically, a health threat is discovered by a State Agency for agricultural policies due to a hazardous pesticide. The State Agency is using the FIspace Product Recall App and sends a request after submitting the relevant information to discover the users of the hazardous pesticide. The traceability service (TS), which has been linked to the business entity, as well as FMIS from several greenhouses are also connected to the business process, in order to provide back information, which the developed FIspace app will use to extract the list of all the involved parties, which need to be notified for the threat.

In the message sequence chart that is presented below (Fig. 12), the process is initiated by a State Agency request

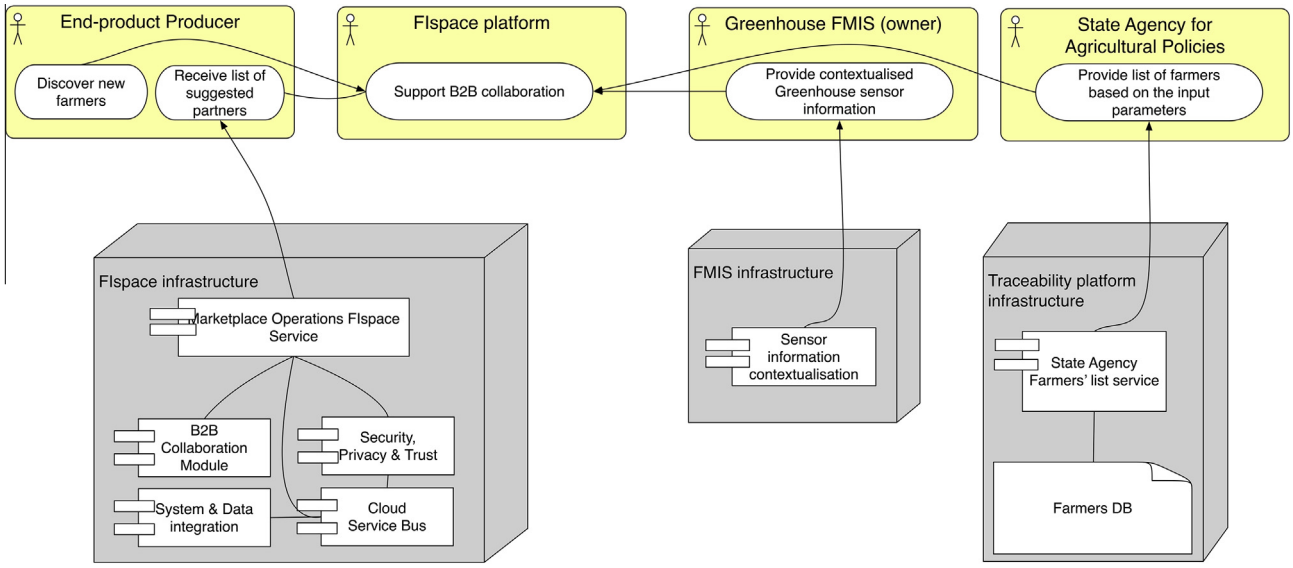

Fig. 9 – Facilitating the search for new collaborations using the FIspace platform.

toward the FIspace platform. The following messages involve the information acquisition from the external parties (Traceability platform and Greenhouse FMIS) and the final feedback that is provided back to the State Agency:

As it is illustrated in the above figure, the request is initially submitted via the SDI module into the FIspace platform. A tight collaboration between two core modules of the platform, i.e., Event Processing and Business Collaboration modules is in charge afterward of the overall coordination of the flow of the messages and the final notification to the user via FIspace's front-end.

4.5. *Greenhouse trial business process modeling via the notion of business entities*

In order to provide further insights to the operational model of the FIspace platform regarding the business entities (BEs) of the greenhouse trial, the GSM model of the BEs for two of

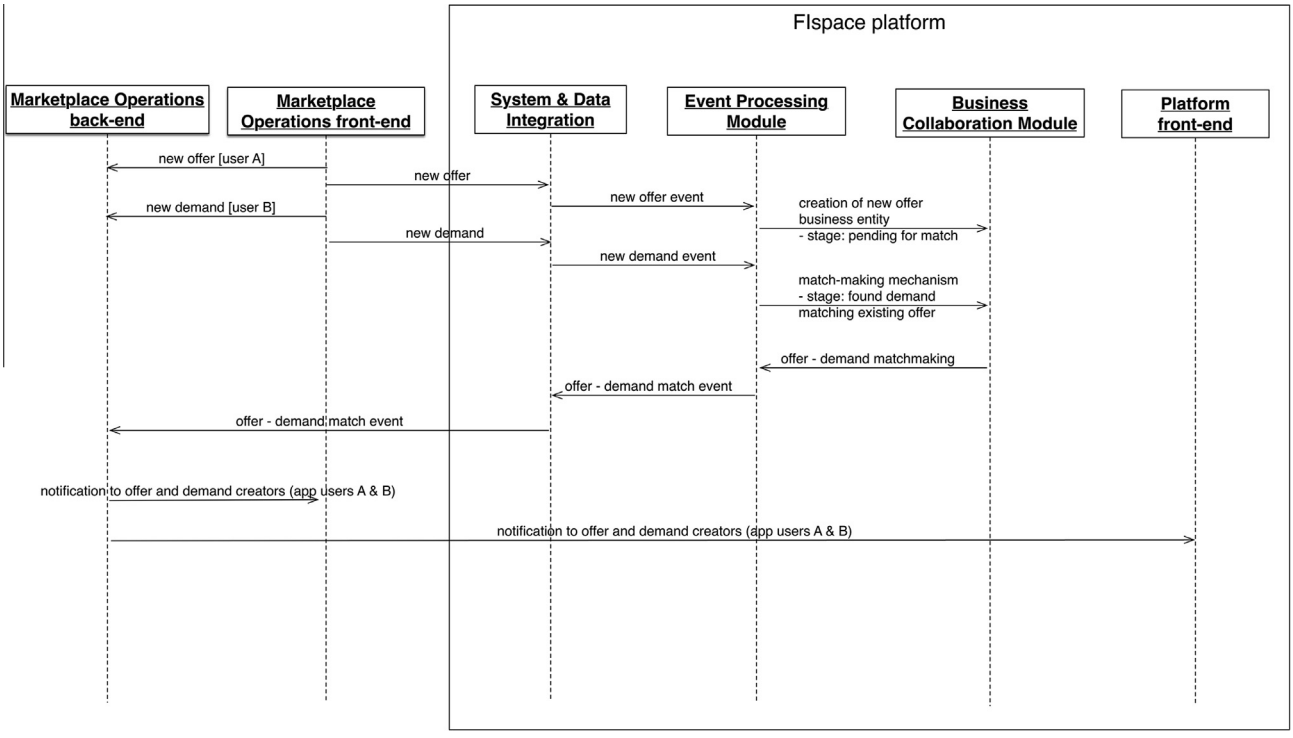

Fig. 10 – MSC for the New Collaborations scenario.

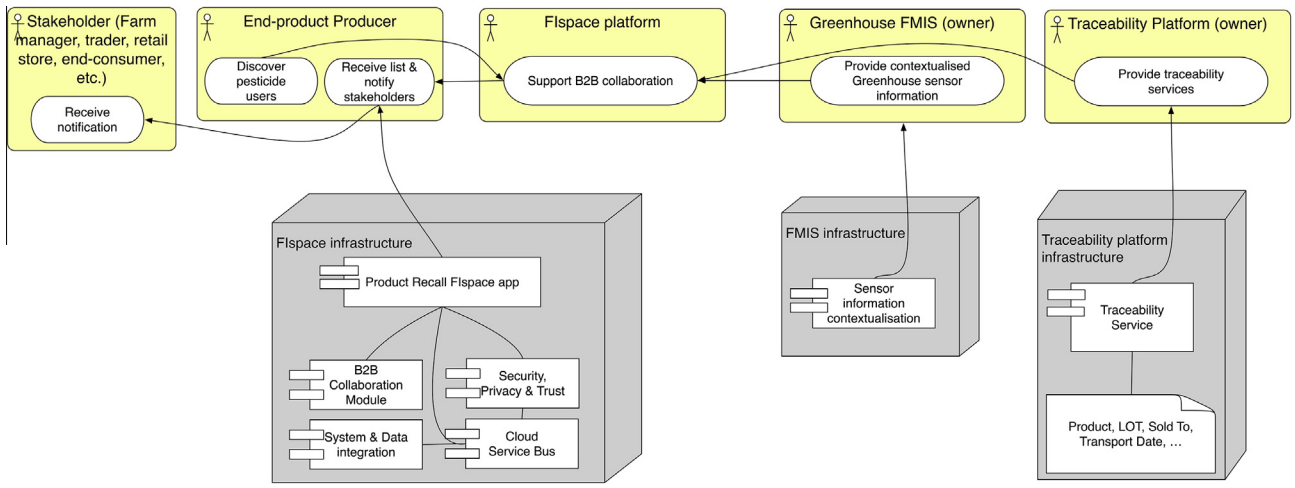

Fig. 11 – Collaboration for recalling a product from Agricultural State Agency.

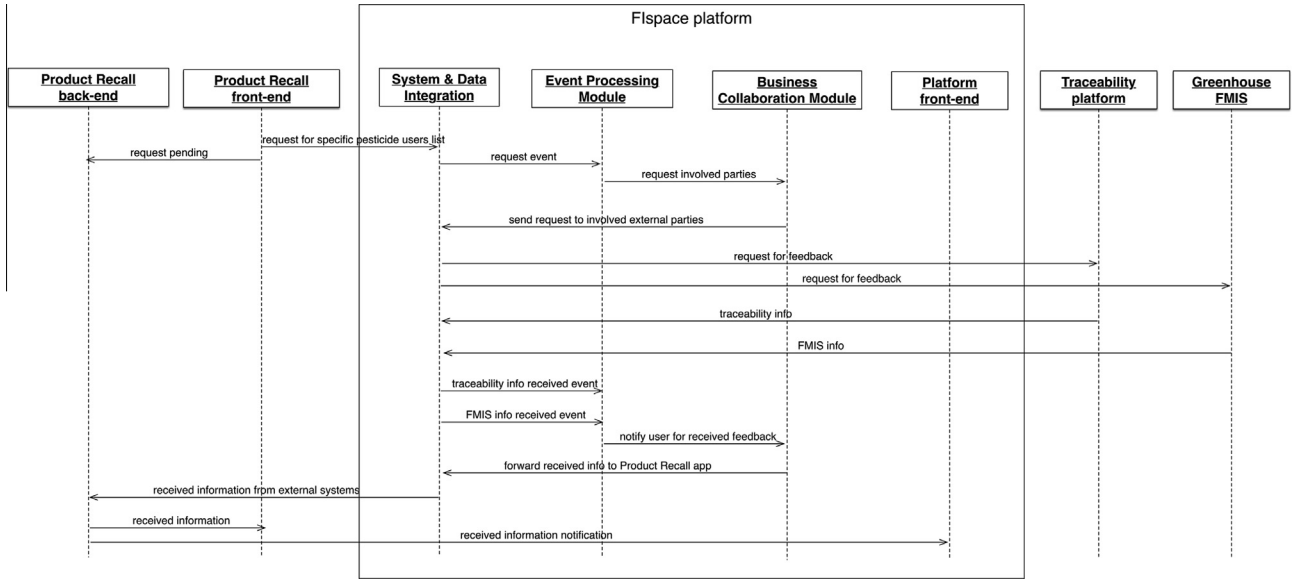

Fig. 12 – MSC for recalling a Product scenario.

the afore-presented scenarios (namely "Requesting for Greenhouse Advice from an Expert System" and "Managing Consumer Complaints") is illustrated below (Figs. 13 and 14). The BEs are: Advice BE (represented by the Advice GSM) and ComplaintAnalysis BE (represented by the Complaint Analysis GSM) respectively. These BEs are linked to the apps residing inside the platform, which were presented in the technology layer of the respective scenario.

The first figure (Fig. 13) illustrates the advice business entity lifecycle (GSM model) for the greenhouse, requested by the FIspace platform, and generated by the expert system. Respectively, the second one (Fig. 14) shows the BE lifecycle (GSM model) of the Managing Complaints use case. We highlight in Table 1 below the main steps of one of the two GSM models (Advice BE – Fig. 13), in order to demonstrate the role of the business entity in the lifecycle of the collaboration process.

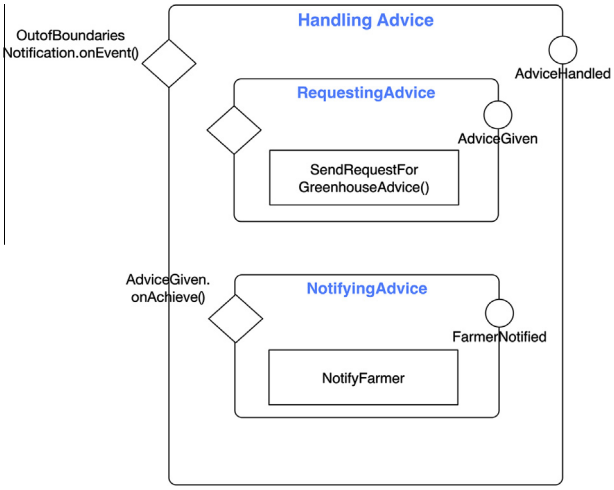

Fig. 13 – Advice GSM.

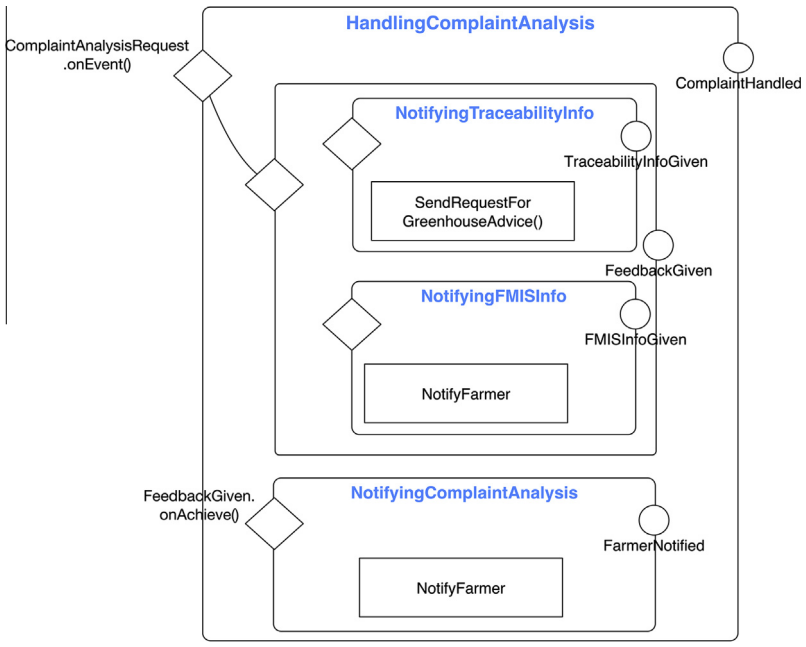

Fig. 14 – Complaint Analysis GSM.

Table 1 – Request for Advice from Expert System scenario.

Scenario steps	Respective progress of the Advice BE GSM model
• Greenhouse sensor values are being constantly monitored by the EPM. At some point in time one or more sensor values that exceed pre-defined thresholds, are detected and as a result the EPM emits the OutOfBoundariesNotification event to the BCM • Expert system responds back with required advices/ actions after receiving the values • The expert system notifies the FIspace platform that the advice is given to the greenhouse FMIS • A notification is created inside FIspace platform for the farmer, visible upon entering FIspace and opening the Advice app	• An OutOfBoundariesNotification. onEvent() is received and the process enters the HandlingAdvice stage, and more specifically the RequestingAdvice sub-stage • SendRequestForGreenhouseAdvice action is activated • AdviceGiven milestone is reached upon successful receiving the requested Advice • The AdviceGiven.onAchieve() guard is passed and NotifyFarmer is activated • FarmerNotified is reached – AdviceHandled is reached – HandlingAdvice stage ends

Of course, more complex collaborations can be accomplished by combining BEs along with their respective GSM models.

5. Discussion and conclusions

In this conceptual paper we presented how FIspace, an innovative B2B collaboration platform, will reshape modern business collaborations with the help of the afore-presented notion of the business entities. A B2B collaboration core module is used for the orchestration of such business processes, as the complexity of future collaborations will require diverse parties participating, multiple data types and standards being used for the accomplishment of a single collaboration, as well as huge number of events that need to be handled appropriately.

Furthermore, a critical perspective that needs to be highlighted is the facilitation of integrating existing legacy systems (e.g. FMISs, Advisory Systems, etc.). This is realized by minimizing the required effort to harmonize the communication schemes between the platform and these systems. This harmonization is achieved via another crucial module of the B2B scheme, the System and Data Integration module of the platform.

From the agri-food domain's perspective in particular, via the greenhouse management and control trial's developments that were provided, a completely novel way of linking diverse business stakeholders and external systems – previously completely disconnected – is presented. The architecture, as well as the operational model of the platform that were also presented in detail, set the foundations to establish Future Internet-enabled software tools, making FIspace one of the cornerstones of the forthcoming Business-to-Business technological solutions in the near future.

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